safe CREW

POLICY BRIEF

28 FEBRUARY 2026

MANAGING THE TRANSITION FROM NON-DISINFECTED TO DISINFECTED DRINKING WATER SUPPLY SYSTEMS

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Recommendations for disinfection

- **If the water distribution network is well-maintained, UV disinfection is highly recommended.**

- **The selection of disinfectants depends on source water and network conditions. Sodium hypochlorite (NaOCl) or chlorine dioxide (ClO_2) are generally recommended, while chloramine may be preferred in certain cases. For ClO_2, on-site generation, cold storage, and frequent monitoring of chlorite and chlorate are required, avoiding long-term storage. For NaOCl, storage time and temperature must be optimized to prevent chlorate formation considering site-specific factors.**

- **Disinfectant dosing should be kept at the minimum required to maintain microbial water safety. Advanced monitoring and automated dosing systems help achieve precise control, reducing the formation of regulated disinfection by-products (DBPs).**

- **Water utilities should implement or optimize treatment technologies, such as coagulation/flocculation, ozonation, activated carbon, or selective membrane adsorption, to selectively remove natural organic matter (NOM) that serves as precursor for regulated DBPs.**

- **Water utilities should use predictive or metamodel-based systems to optimize disinfectant dosing and minimize DBPs.**

Context

Climate change and global development are increasing the complexity of water pollution, exposing the limits of conventional drinking water treatment. Rising temperatures and extreme hydrological events elevate contamination risks and increase conditions that promote disinfection by-product (DBPs) formation when chemical disinfection is introduced. Protecting public health might require transitioning to disinfected drinking water supply systems. This transition should be supported by advanced water treatment technologies that avoid or control the formation of DBPs while safeguarding microbial water quality.

There is no centrally harmonized EU-wide list of national standards governing the use of disinfectants in drinking water. Instead, regulation is based on the EU Drinking Water Directive (EU) 2020/2184, which sets out general quality and hygiene requirements, while each EU Member State implements these requirements through its own national legal instruments. Below are examples of national implementing provisions (laws/regulations) in which the use of disinfectants in drinking water is regulated or may be regulated, in some cases including lists of authorized treatment substances. These provisions implement and/or further specify the EU requirements (often in technical detail) and define which disinfectants and treatment processes may be used in drinking water and under what conditions.

Member State	National Regulation / Standard
Austria	*Drinking Water Ordinance (TWV, Federal Law Gazette II No. 304/2001, as amended)*
Belgium (regions)	Regional water and drinking water legislation (Flanders, Wallonia, Brussels)
France	*Code de la santé publique* (drinking water provisions)
Germany	*Ordinance on the Quality of Water Intended for Human Consumption (Drinking Water Ordinance – TrinkwV, incl. §11/§20 List)*
Italy	*Legislative Decree of 23 February 2023, No. 18, as amended by Legislative Decree No. 102 of 2025, regulating the quality of water intended for human consumption*
Netherlands	*Drinkwaterbesluit (Drinking Water Decree)*
Spain	*Royal Decree 3/2023, of 10 January, which establishes the health and technical criteria of water intended for human consumption, and the control and supply of same.*
Sweden	*Livsmedelsverket – Drinking Water Regulations*
Ukraine	*State Sanitary Norms and Rules "Hygienic requirements for drinking water intended for human consumption" (2.2.4-171-10)*
United Kingdom (GB, formerly EU)	*The Water Supply (Water Quality) Regulations*

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Under the current legal framework, there is generally no “unconditional” obligation within the EU to disinfect drinking water in all cases. The EU Drinking Water Directive requires drinking water to be “wholesome and clean” (i.e. microbiologically safe), while leaving Member States discretion as to the measures used to achieve this objective.

Disinfectants must comply with EU Regulation No 528/2012 of 22 May 2012, which governs the sale and use of biocidal products. ECHA maintains a list of authorized biocidal products for each Member State.

Disinfection by-products (DBPs)

DBPs are produced when disinfectants (free chlorine-derived oxidants, chloramines, chlorine dioxide, or ozone/UV in hybrid trains) react with natural organic matter (NOM), which is the main precursor. NOM is often operationally measured as TOC (total organic carbon), or UV_{254} (ultraviolet absorbance at 254 nm).

Although NOM provides the carbon backbone, the presence of bromide and iodide can shift DBP formation towards brominated or iodinated DBPs, which are often more cytotoxic and genotoxic. Therefore, DBP precursors can be summarized as NOM + Br^-/I^- + operating conditions (disinfectant type, pH, dose, contact time, temperature).

Key NOM “sub-pools” and typical DBP outcomes

- Humic/fulvic, aromatic NOM (high Specific UV Absorbance SUVA /UV_{254}): tends to drive carbonaceous DBPs (C-DBPs), especially the EU-regulated trihalomethanes (THMs) and haloacetic acids (HAAs) under chlorination.
- Protein-/amino-acid-/nitrogen-containing NOM (dissolved organic nitrogen (DON), algal organic matter, wastewater-impacted NOM): tends to increase formation potential of nitrogenous DBPs (N-DBPs) (e.g., haloacetonitriles, haloacetamides, nitrosamines).
- Sulfur containing NOM in source waters seems to be the precursor of a larger group of new, unregulated DBPs under chlorination. Currently NOM precursor strategies target mainly humic/fulvic aromatic NOM to control regulated DBPs formation under chlorination which may lead to no positive effects for the reduction for sulfonated DBPs.

Characterisation of the water matrix should be performed before selecting and dosing disinfectants. As NOM composition can vary seasonally, year-round monitoring is recommended. Combined with DBP formation potential tests, this enables a robust risk assessment and supports selection of the most appropriate disinfection strategy.

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Solutions

In water supply systems without continuous disinfection, such as those in Hamburg or Berlin, the application of a permanent disinfectant residual would be a secondary option, as UV disinfection can largely prevent the formation of DBPs within the distribution network.

SafeCREW confirmed the effectiveness of regulated DBP reduction strategies in chlorination-based disinfection, including coagulation/flocculation, ozonation and activated carbon (full scale, Tarragona), granular activated carbon adsorption (full and lab scale, Milan)[1,2,] and selective membrane adsorbers (laboratory scale, Hamburg)[2]. Results demonstrate that, with the support of advanced analytical techniques (e.g., size exclusion chromatography, fluorescence spectroscopy with PARAFAC analysis, and FT-ICR-MS), it is possible to selectively target NOM precursor fractions using specific water treatment technologies that contribute to the formation of EU-regulated DBPs. These findings are relevant specifically for disinfection practices based on free chlorine and for controlling the formation of THMs and HAAs. It is important to note that in some cases, existing treatment facilities can be optimized to improve the elimination of the DBP precursors.

DBP formation is directly correlated to the amount of disinfectant that is used. To avoid dosing in excess, online monitoring and dosing automation has shown excellent results in treatment plant and distribution network (full scale, Tarragona).

If disinfection with permanent disinfectant residual is applied, a DBP prediction model (for THMs, HAAs and HANs) can be implemented if chlorine residual, temperature and residence time are continually monitored in strategic points of the network. This will allow the creation of a control system to optimize the network operation and increase the safety of the final users.

Conversely, when only a limited set of informative measurements can be routinely collected and models cannot be applied, metamodels shall serve to provide an operational, evidence-based framework for reasoning about disinfection control[3]. In detail, metamodels support organising heterogeneous signals (e.g. operating data, chemical measurements, NOM fingerprints, microbiological activity and toxicity bioassays) into comparable scales, and identifying plausible, simple, interpretable relationships that can inform proportionate adjustments to dosing and operating conditions.

[1] Deliverable D2.3 SafeCREW – Application guideline about disinfection-by-product precursor removal by different materials

[2] Deliverable D2.4 SafeCREW – Report on natural organic matter transformation via ozone oxidation and advanced oxidation processes

[3] Deliverable D2.5 SafeCREW – Meta-model to support routine management of disinfection

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Need for further research

The project revealed the formation of a "new" class of sulfonated DBPs[4]. However, the project has not determined their actual abundance, toxicity, or underlying formation mechanisms; further dedicated research is therefore necessary and strongly recommended.

Another important issue concerns the potential release of substances into water from materials in contact with drinking water. This challenge is particularly relevant in areas affected by human activities, where pipe relining has become an increasingly common solution for rehabilitating ageing water infrastructure, as it minimizes construction works and service interruptions. However, epoxy resins used in relining applications may release compounds that are toxic themselves or that can form toxic by-products through reactions with chemical disinfectants. In addition to the well-documented potential release of bisphenols, the monitoring campaign conducted within the SafeCREW project identified the presence of nitrosamines, specifically NDMA (N-nitrosodimethylamine) and NMOR (N-nitrosomorpholine). Both compounds were detected before and after relining, suggesting multiple possible sources. These include: (i) direct release from multiple materials in contact with water, including epoxy resins, chemicals used in their polymerization, and other pipe-contact materials; and (ii) the formation of nitrosamines through reactions between released nitrogen-containing compounds and chemical disinfectants, such as sodium hypochlorite. For example, NMOR may be present in rubber components and used as an additive in plastic pipes; however, information on its toxicity to humans remains limited, highlighting an important knowledge gap that warrants further investigation.

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[4] Deliverable D1.1: SefeCREW - Advanced analytical procedures for the characterization of disinfection by-products and methodology for remote sensing of natural organic matter

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